DEFENSE SYSTEMS MANAGEMENT SCHOOL

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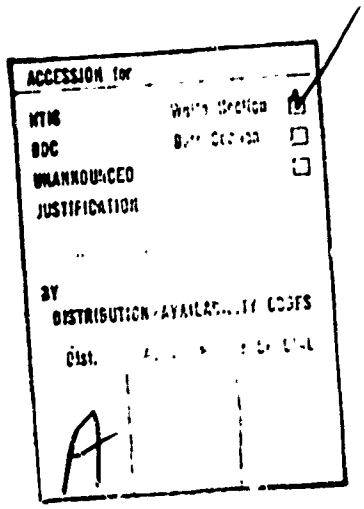
INDIVIDUAL STUDY PROGRAM

RELIABILITY AND MAINTAINABILITY
vs.
FLEET READINESS

STUDY PROJECT REPORT
PMC 74-2

LCDR F.W. Boufford USN

FORT BELVOIR, VIRGINIA 22060



RELIABILITY AND MAINTAINABILITY vs. FLEET READINESS

Study Project Report

Individual Study Program

Defense Systems Management School

Program Management Course

Class 74-2

by

LCDR F.W. Boufford USN

November 1974

Study Project Advisor

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This study project report represents the views, conclusions, and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management School or the Department of Defense.

DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: RELIABILITY AND MAINTAINABILITY vs. FLEET READINESS

STUDY PROJECT GOALS:

To review Navy policies in the area of reliability and maintainability.

To evaluate the adequacy of current Navy policies for reliability and maintainability when considered against the goals promulgated by the Chief of Naval Material in December of 1973

STUDY REPORT ABSTRACT

The report reviews the conditions and causes which led to a restatement of Navy Reliability and Maintainability Goals by the Chief of Naval Material in December of 1972. The results of the Wheeler Ad Hoc Committee for Mean Time Between Failure Improvement are summarized. Specific (unclassified) examples of equipments and management practices leading to undesirable reliability and maintainability are then presented. The study report then traces the development of the NAVMAT Reliability and Maintainability Directorate. After identifying new policies initiated by the directorate, an evaluation of current Navy R&M policy and programs is developed.

KEY WORDS

RESOURCES READINESS COMBAT READINESS RELIABILITY
MATERIEL ACQUISITION POLARIS MTBF

MAINTAINABILITY
PROJECT MANAGEMENT

NAME, RANK, SERVICE	CLASS	DATE
LCDR F.W. Boufford USN	PMC 74-2	November 1974

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) RELIABILITY AND MAINTAINABILITY vs FLEET READINESS		5. TYPE OF REPORT & PERIOD COVERED Student Project Report 74-2 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) F. W. Boufford		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Defense Systems Management College Ft. Belvoir, VA 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Systems Management College Ft. Belvoir, VA 22060		12. REPORT DATE 74-2 13. NUMBER OF PAGES 40
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

XXXX SEE ATTACHED SHEET

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

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EXECUTIVE SUMMARY

In December of 1973, the Chief of Naval Material, Admiral I.C. Kidd, Jr. USN issued a memorandum which provided new direction and goals for Navy Acquisition Managers to follow in 1974. This research project reviews the need and condition which caused the memorandum to be issued.

Although the research indicates that the Navy had attempted to improve equipment performance through increased emphasis on reliability and maintainability in the years following World War II, the most serious and concentrated effort appears to have been initiated by Adm Kidd shortly after he assumed command of the Navy Material Command. His operational experience as Commander Sixth Fleet had provided sufficient justification for Adm Kidd to recognize that reliability and maintainability must be key elements in a weapons system acquisition program if the equipment is to improve overall fleet readiness.

In May of 1972, the first new major study on R&M improvement was issued by the Mean Time Between Failure Improvement Study Group headed by the Commander of the Naval Supply Systems Command, RADM K.R. Wheeler SC USN. This detailed study into current Navy practices clearly outlined the problem and documented the deficiencies. And, the conclusions

and recommendations of the Wheeler Report appear to have become the basis for the current NAVMAT effort to improve reliability and maintainability.

Shortly after the completion of the Wheeler Study, serious efforts to improve the R&M capability of the NAVMAT staff began. A seperate office was created under the leadership and direction of a NASA R&M expert. The organization was also placed under the administrative control of the DCNM for Operation (MAT -06).

After approximately one year of operation, the NAVMAT R&M office was elevated to the status of directorate with a MAT ØØ code. The initial efforts of the office have been directed at providing leadership and guidance for the hardware systems commands in achieving the goals established by Admiral Kidd. In this regard, specific recommendations have been provided which if adopted, would result in a revised approach to R&M testing. Stressing systems engineering concepts, this innovative procedure would require the Navy acquisition management to develop mission profiles, solid designs and pre-determined test programs. The essence of these concepts is an early identification of R&M requirements relative to mission and then a continuous review of cause of equipment/system failure during development stages.

Based on the evidence developed during the study, it appears that the Naval Material Community has made substantial

initial steps toward resolution of R&M problems. However, the final goals of the program can only be achieved if top level management recognizes the life cycle importance of R&M. As long as these important elements of the acquisition effort are used as trade-offs, the overall success of reliability and maintainability in the Navy cannot be assured.

PREFACE

Prior to selection and assignment to the Defense Systems Management School, I was assigned to duty in the Command Center of the Naval Material Command, an organization which functioned in direct support of Admiral I.C. Kidd, Jr. USN, The Chief of Naval Material. While serving in this billet, I was exposed to a copy of a memorandum, dated 10 Dec '73, which Admiral Kidd sent to his Systems Commanders addressing concepts of reliability and maintainability. The principles expressed in this memorandum reflected concepts that I developed in earlier operational tours at sea. As an officer in modern destroyer type ships, I have become more and more convinced that the complexity of our modern naval systems has far exceeded the capabilities of our average enlisted technician. This fact coupled with an exceptionally heavy tempo of operations seems to be the primary cause of the continuing material readiness problems which have degraded the operational efficiency of the fleet at sea. The purpose of this paper is to research concepts of reliability and maintainability utilizing a relatively subjective operator's viewpoint. The ultimate goal will be to identify those specific management actions that Navy Program/Acquisition Managers can or have implemented in order to improve overall

equipment/system reliability and thereby increase fleet operational readiness.

SECTION I

INTRODUCTION

In December of 1973, the Chief of Naval Material, Admiral Isaac C. Kidd, Jr. USN, issued his so-called Christmas '73 memorandum to Navy Systems Commanders, Major Project Managers, and Deputy Chiefs of Naval Material. This memorandum defined goals in the area of reliability and maintainability which the Navy acquisition community was to meet during 1974. In the establishment of these goals Admiral Kidd stressed the follow - ing points:

1. Equipment and supporting documentation would be designed to the educational level of comprehension of the average sailor.
2. A specific standard of performance without failure was established for all commodities which the Navy invents, contracts for, or produces.
3. In the event that a system/equipment could not meet the promulgated standard, redundancy or alternative methods of control were to be provided.
4. Reliability and maintainability inspections were to be uncompromising. (14)

These four principles or concepts were to become the standards for a renewed Navy emphasis on reliability and maintainability - - - an effort to improve Fleet Readiness

by providing the operating forces with better equipments and systems.

It is the purpose of this study project to conduct a review of Navy Reliability and Maintainability policies to determine the impact of Admiral Kidd's direction. As a goal, I have chosen a definition and determination of the adequacy of current Navy programs when considered in light of earlier policy, studies, and direction. The paper will look at current standards used by Navy acquisition management and attempt to relate their effectiveness in implementing policy and direction.

During the course of this paper, normal Naval Material Command terminology and acronyms will be used. Certain Navy instructions, notices, memorandum and other studies have been used as primary reference materials and are so listed in the bibliography. Classified studies are also indicated. In addition, interviews with major participants in the NAVMAT Reliability and Maintainability Office were also conducted. These interviews are noted in the bibliography section of the paper.

This research paper will be limited to the surface ship branch of the Navy material world. Although the vast impact and importance of the Naval Air Systems Command Acquisition efforts is recognized, the thrust of the project will be directed at the ship oriented programs under the cognizance

of the Naval Sea Systems Command and the Naval Electronics Systems Command.

The study project will also concentrate on management policy or practices. It is recognized that specific formulas and models are available to the R&M specialist. However, the review of these specific quantitive factors is considered to be beyond the scope of the paper.

SECTION II

BACKGROUND

> Our Fleet is becoming so saturated in complexity that I have a mortal fear that we might be sailing on a collision course with something dreadful - like not being able to take the Fleet to sea and fight. (10/1-2)

> The ever increasing complexity of shipboard equipments continues to add to the already overextended training requirements. The acceptance of shipboard equipment which exceeds the capabilities of Navy personal to maintain can only result in a loss of Fleet Readiness. (10/1-2)

The thoughts and concepts contained in these two quotations could easily have been expressed by the current Chief of Navy Material, Admiral Kidd. They are however expressions of concern that were made respectively by the Atlantic and Pacific Fleet Commanders in the early 1960's. These statements do express the vital need for a renewed stress on equipment reliability.

During Admiral Kidd's initial years at NAVMAT, he continually placed strong emphasis on improved reliability in the hardware, equipment and systems that were being provided to the operating forces of the Navy. His concern was not reliability per se - but rather the impact that the lack of reliability in offensive and defensive systems could have on fleet

readiness. During these initial years, he cited statistics indicating that 4.7 supply flights per week were required to keep fleet ships operational; that three atack carriers were required to provide the inherent firepower of one attack carrier; and that the fleet was connected to the shore support activities by an "umbilical to the beach." (21) As an operational commander who had just completed a tour as Commander, Sixth Fleet, Admiral Kidd brought to the Naval Material Command a keen and current understanding of the need for increased reliability in fleet units.

This conviction was re-emphasized during a SECNAV Readiness Brief on 10 Feb 1972. At that time, a CINCPACFLT briefer stated that many key equipments are designed with Mean Time Between Failure (MTBF) Requirements which are seriously degraded in actual employment. (5/1) As a result an ad hoc committee, chaired by the Commander of the Naval Supply Systems Command, RADM K.R. Wheeler SC USN, was established within the Naval Material Command. The results of the study-now commonly referred to as the "Wheeler Report" - addressed ways to reduce the gap between promised failure rate and actual operational availability. It is significant to note that during the course of the development of the Wheeler Report, certain CNM Action Sheets were issued to support the efforts of RADM Wheeler's ad hoc group. (CNM Action Sheets 69-72 and 106-72). The study group received support at the

highest levels of command within the Naval Material Commands.

It is also significant to note that the Wheeler Report was not the first Navy effort directed toward the resolution of reliability vs. fleet readiness. Rather, there appears to have been a continuing effort toward definition and resolution of the problem. For example, in early 1947, the Navy reported that 70% of electronics equipments did not operate in a satisfactory manner. (2/1-1) A follow-on Navy study indicated that over 50% of Navy R&M problems were caused by manufacturing defects (28%) and design deficiencies (20%).(2/1-2) Throughout the 1950's the efforts to resolve R&M problems continued. (For example, the 1952 DOD Advisory Groups on the Reliability of electronics equipment and/or the 1958 ad hoc committee for guided missile reliability.) (2/2-4) However, the current emphasis, initiated by Admiral Kidd, appears to be more sustaining than earlier efforts.

SECTION III

THE WHEELER REPORT

Up to this point, no specific definition has been applied to the words reliability and maintainability. In the process of their review, the Wheeler Study Group determined that Fleet use of the term low "reliability" may in the language of the producers mean the same as poor "availability," poor "logistic support" or low "reliability." (5/1)

Therefore, in order to establish a common basis of reference, the following definitions will be used for the duration of this paper.

> Reliability is the performance characteristic of equipment that reflects its ability to operate satisfactorily long enough to perform its mission. Reliability is an index of the excellence of design. (2/1-16)
>
> Maintainability is the speed or economy with which a system or component can be kept in, and/or restored to field performance capability. (2/2-2)

And, in further elaboration

> Reliability requirements are defined by
> - The importance of the systems.
> - Use of the system.
> - Acceptable downtime.
> - Relation to other systems. (2/1-16)

With these agreed upon definitions in hand, a review of the findings of the Wheeler Report is now necessary in order to establish the problem area.

In broad general terms the Wheeler Ad Hoc Group concluded that those equipments found unreliable in the fleet simply did not have reliability designed in from the beginning and were generally unreliable whether tested ashore or at sea. The primary problem identified was lack of reliability built into equipments from the beginning. The report indicates that it would be necessary for the Navy to modify procedures, cost allocations and management attitudes to achieve a goal of improved reliability. (5/2)

In an accompanying memorandum, the Wheeler Group cited specific conditions existing in 1972 which were considered to be crucial factors influencing reliability in Navy acquisition efforts. Summarized, these factors were:

1. Sufficient time and dollars omitted from budgetary submissions.
2. Unenforceable reliability goals in contracts. No enforceable reliability requirements.
3. Poor or non-existent reliability testing procedures.
4. Insufficient reporting systems to identify unreliable equipments in the fleet.
5. Pressure for attaining specified performance goals which leads to trade-offs that, though not explicit, aggregate to lower reliability.

6. Poor documentation of trade-offs between reliability and performance. (9/3)

The Wheeler report then concluded with the recommendation that reliability should be of such crucial importance that top management should have explicit knowledge of its degradation when certain cost, delivery, and performance decisions are made. And the Navy must be prepared to pay the price if "we really intend to achieve reliability in our new ships and aircraft." (5/4)

The in-depth specific recommendations of the Wheeler Group covered the following main (and summarized) points:

A. Immediate Management Activities: The Group called for policy statements covering, but not limited to, the inclusion of reliability programs in all future budget statements, non-acceptance of any mission related equipment which fails to meet required reliability, enforcement of reliability policy by line management within the Systems Commands and personal policy statements issued by the Chief of Naval Material.

B. Immediate Organizational Actions: The group called for audits of APP's, and other procurement requests to determine the extent of compliance with reliability policies. In addition the establishment of a focal point for reliability on the NAVMAT Staff was recommended.

C. Procedures for Immediate Implementation: The group recommended that immediate action be initiated to verify that specifications contain proper schedules to provide for the performance of reliability engineering and - perhaps most important - that the policy for non-acceptance for installation in ships or aircraft those equipments which do not meet reliability requirements be carried out.

D. Intermediate/Long Term Management Actions: The group also promulgated a total of 16 specific long term actions which NAVMAT component organizations could initiate to effect reliability improvements. The emphasis was placed on standardization and audits/checks and balances. However, it is significant to note that the group stressed that Specific Operational Requirements (SOR's) should be explicit concerning reliability required. (5/Encl 1)

This then was the beginning of the current NAVMAT emphasis on reliability and maintainability. The Wheeler Ad Hoc Committee had produced a detailed review of reliability in Navy equipments. A summary of the unclassified sections has been presented above. In the classified sections of the report, specific equipment analysis for both ship and aircraft systems is presented. These studies contain specific detail including system description, points of weakness, corrective action, responsibility, trade-offs and summaries of major equipments that may be of interest to future program/

acquisition managers in formulating plans for the incorporation of reliability requirements in specific procurement plans.

SECTION IV

CASE STUDIES/TECHNICAL BRIEFS

Volume II of the Wheeler Report provides detailed and specific examples of current Navy R&M problems. Because of its classified nature, this data cannot be presented in this paper. However, in an attempt to provide useable examples, Mr. W.J. Willoughby, the current NAVMAT Reliability and Maintainability Director was interviewed. In response to the inquiry for specific examples of poor reliability in surface ships, he produced a power supply for an AN/AQQ-5 submarine sonar and used it to focus on actual problems and defects. Problems cited and exhibited were:

A. Poor Soder Craftsmanship: The AN/AQQ-5 power supply which had been removed at random from a fleet unit was considered to be a complete example of poor sodering techniques. Wires were not wrapped on posts or connections. Amounts of soder and applications varied on the individual connections. Investigations into the causes revealed that the Navy had no current, up to date, specification or procedure which could be used as a performance standard.

B. Component Location: The unit had 20 fuses which were stacked and not readily accessible. Replacement of the last fuse in the stack would require removal of all others.

Positive and Negative terminals were not clearly marked. Location of positive and negative terminals alternated throughout the fuse stack.

C. Component Protection: The BQQ-5 power supply had several locations where wires were laid across sharp edges with no protection or chaffing gear. Even a small level of vibration would cause potential breaks in the insulation of these wires. (23)

Basically, this BQQ-5 power supply was exhibited as an example of poor design, poor craftsmanship and poor specifications. As a result, the unit had demonstrated low reliability performance in actual fleet operations. These problems have been subsequently resolved and the equipment is approaching reliability requirements. (25)

A second example of poor reliability was the MK 92 Fire Control System which is programmed for installation in the Navy's new Patrol Frigate Class. In this case, the contract specified environmental qualification tests and reliability tests as optional terms. Incredibly, there was no original plan for actual testing to be conducted by Navy operational personnel to demonstrate that the equipment could be a reliable system when turned over to the fleet. This problem was ultimately resolved through contract modifications. The equipment was tested by average operator personnel at a land based test site. (21)

A final example of reliability problems facing the Navy today was associated with the systems installed in a major AAW shipbuilding program. In this case, it was determined that the ship did have a reliability allocation for the majority of the mission-related equipments. However, these allocated reliability numbers were based on a short (few hours) AAW mission and therefore resulted in unrealistically low Mean Time Between Failure (MTBF) requirements. In addition, it was determined that the shipbuilding contract placed no requirement on the shipbuilder to meet reliability requirements allocated to equipment that he would buy or build. A further investigation determined that all of the major mission related equipments in the ship's combat system had individually passed reliability demonstrations. However, the requirement to demonstrate the reliability of the entire system remained unrealistically short. (5/Vol II) Apparently, no one had given any consideration to the fact that while an AAW engagement may only last a few hours, countless operational hours are spent in patrol, escort and deterent roles.

SECTION V

CURRENT STATUS

Based on the information presented in Sections III and IV above, it appears that the Navy material acquisition community has made significant steps toward the identification of the causes of poor reliability. It is now time to look at corrective actions and evaluate relative effectiveness.

Shortly after the completion of the Wheeler study, Admiral Kidd arranged the transfer of a key member of the NASA reliability program, Mr. W.J. Willoughby, to the NAVMAT staff. Administratively, this expert and his nucleus reliability office were assigned to the Deputy Chief of Naval Material for Operations (MAT 06), RADM John Thomas USN. Specific duties, as defined in the NAVMAT Organization Manual were:

> Reliability and Maintainability Office (MAT 06H) serves as the NMC focal point for Reliability and Maintainability (R&M) matters and acts for the Chief of Naval Material to insure the adequacy of R&M planning, direction, integration and evaluation of R&M in all programs in conceptual, development, production, test, and operational phases. These responsibilities include:
>
> a. Initiating necessary plans and directives to fully implement an effective NMC R&M program.
>
> b. Assuring that adequate and realistic R&M programs and requirements are included in all applicable planning and acquisition documents

(DCP's, APP's, RFP's, TDP's, etc.).

c. Monitoring SYSCOM and PM weapons system R&M reviews; and in coordination with Program or Acquisition Managers initiating R&M reviews of various programs on an ad hoc basis.

d. Maintaining continuous liaison with Fleet activities and Type Commanders to insure that proper attention is given to current Fleet R&M problems, and that such problems are not being repeated in systems under development.

e. Providing recommendations to the VCNM for reorientation or termination of programs in which R&M achievements are unsatisfactory.

f. In coordination with the DCNM (Development), providing technical direction to the R&M Initiative Program established by the ASN (R&D) for the promotion of reliability growth of systems in development and to the correction of Fleet R&M problems. (9)

In addition, Admiral Kidd specifically included reliability and maintainability as an essential element in his mode of operations. In public appearances and speeches, he stressed reliability and his influence and concepts slowly began to influence the technical community. In January of 1973, Admiral Kidd was the keynote speaker at the Annual Reliability and Maintainability Symposium held in Philadelphia. During his remarks, he outlined "Five Challenges in Assurance Technologies". Summarized, the challenges presented to the assembled engineers were:

1. Develop and produce "sailor-proof" equipment.

2. Design equipment for the environment in which it will operate.

3. Develop better capabilities for operational monitoring of complex equipments.

4. Insure common sense in the design of equipment.

5. Halt the growing size of naval vehicles and systems. (20)

And so the team was formed - Admiral Kidd pushing for reliability because it would result in better fleet readiness: RADM Thomas using the command and operational facilities and assets of MAT 06; and Mr. Willoughby, the NASA expert, who saw reliability put man on the moon.

Throughout 1973, initial effort was placed on stressing that equipments must be designed for their operational environments. Emphasis was also placed on design of equipment that was maintainable - equipment that could be maintained with a minimum of training by enlisted technicians. Concepts were formulated which saw reliability and maintainability as a gate in future Navy contracts. In addition, the NAVMAT Inspector General became involved and incorporated R&M into his routine inspections procedures. A serious effort was made to identify a reasonable and attainable standard of reliability performance. In this regard, studies were made evaluating successful reliability programs. It was determined that NASA

felt that, given good specifications, a reliability goal of 80% was fairly easy to achieve - and that reliability really got difficult and expensive when goals over 90% were established. Finally, a goal of 75% equipment availability (reliability) for a period of 60 days was established. (16) The internal hue and cry of the Navy acquisition staffs was initially quite strong until it was pointed out that this so-called new Navy standard was not really new. Its source was the Navy's Polaris program - a program with proven and accepted success. (?1)

Finally in the summer of 1974, the NAVMAT Reliability Directorate was established with a NAVMAT ØØ code and a reporting channel directly to the Chief of Naval Material. Although the effectiveness of this directorate cannot yet be evaluated, it is significant to note that its charter provides broad responsibilities and authority. In addition to centralizing all Naval Material Command policy on reliability and maintainability, the charter provides that the NAVMAT Director of Reliability and Maintainability shall act as directed by the Chief of Naval Material to:

> Establish a management reporting and control system, such as an Action Center, to insure the effective implementation of policy.
>
> Review procurement on an ad hoc basis to evaluate the effectiveness of directives and instructions.

Enforce NAVMAT directives and instructions through such action as stopping work where contractors programs for reliability and maintainability do not meet standards.

Terminate contracts if necessary.

Develop a uniform cost-effectiveness methodology to derive enforceable reliability and maintainability parameters from operational effectiveness and life cycle cost requirements. (8/Encl 1)

The intent of the NAVMAT R&M Directorate is not to assume management functions normally found in the Systems Commands, but rather to assume review responsibilities which will insure that current programs and planning formulation meets requirements. The implementing instruction (NAVMAT INST 5430.53A) also requires that each hardware systems command establish a reliability and maintainability directorate, with a director reporting directly to the systems commander.

This directive is considered to be extremely strong and has assigned specific powers to the NAVMAT R&M Directorate. It is the strongest expression of responsibility and authority that the research associated with this project has developed. The ultimate effectiveness will now be dependent upon the force/initiative of the Directorate and the acceptance by the acquisition types.

SECTION VI

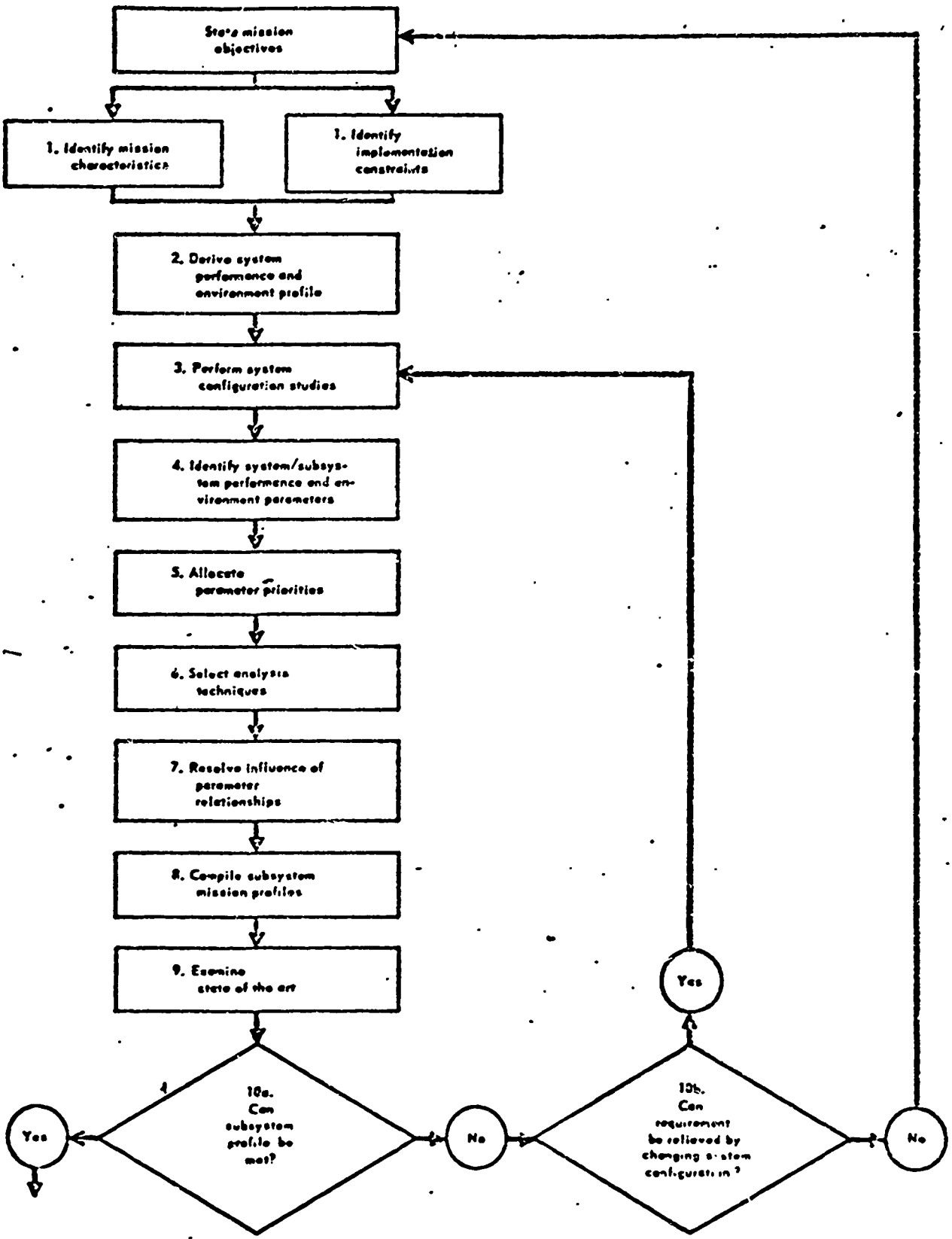
NEW INIATIVES

Now that the Naval Material Command has firmly established hardline requirements for reliability and maintainability in future acquisition efforts, the job of the program manager becomes one of integrating these requirements into his total program. Initially, the basis for achievement of these goals must lie in the development of a mission profile for the equipment or system. This profile must define all significant objectives and constraints that affect the mission. The NAVMAT R&M Directorate is now advocating a ten step method for Navy Program Managers to use in this area. The procedure (illustrated in the attached diagram) transforms the system mission requirements profile into a more detailed set of performance parameters and constraints. The methodology comprises four specific steps:

Identification of parameters which relate functions/operations of lower level elements to those of the overall system.

Prioritizing the parameters in order of importance to mission success.

Resolution of the influences of all parameters from the system to the lower level.



—Profile derivation flow diagram.

(17)

Compilation of parameters and influences into a mission requirements profile. (17)

Using this approach, the program manager/acquisition manager should be able to develop design specifications which will accurately reflect the mission requirements of his program.

Next, the manager must recognize the importance of the design. In this regard, maintainability must be considered to be a function of design concept. Too often Navy programs have not stressed R&M during equipment design periods. Rather numeric goals for Mean Time Between Failure (MTBF) were established. The equipment then reached production without the required reliability or maintainability. The contractor simply was not able to prove the numeric goals. At this point, any improvement to reliability or maintainability became extremely expensive and usually got lost as a trade-off. In-house studies indicate that the Navy could spend 30% less over the life of equipment and still achieve a 50% increase in combat effectiveness, if the proper stress were given to R&M design. (21)

Associated with design is the requirement that solid specifications be cited in any contractual document. The example of the BQQ-5 power supply noted earlier reflects the impact of poor design and specifications on reliability. It will also be necessary for the Navy to move from the concepts of logistic maintenance which seem to have characterized

previous procurements. Early concentration on design can produce positive results in reliability and resultant improved fleet readiness. But the acquisition manager must provide the concentration.

In addition to the development of sound mission profiles, designs, and specifications, a requirement for adequate testing to demonstrate reliability also is extremely important. As indicated earlier, previous Navy practice has been to establish some numeric MTBF goal and then attempt to achieve the goal. Use of this numerical concept places the principle burden of proving reliability - hardware achievement on the service not the contractor. (15)

An alternate approach now being recommended is the development of a contractual requirement to invoke specified engineering disciplines and management controls in order for the contractor to prove reliability. The disciplines recommended include stress analysis, derating, effects analysis, and environmental testing. (15)

The accompany chart reflects the anticipated inter-relationships between hardware acquisition phases, program reviews and certification. In order for the Navy manager to improve control of the contractors reliability efforts, it will be necessary to do technical homework in the form of definition or reliability trade-offs studies, missions and profile analysis and identification of sound test programs. The Naval

CERTIFICATIONS WHEN SPECIFYING CONTROL AND DISCIPLINE REQUIREMENTS

PROGRAM PHASES	EXPLORATORY DEVELOPMENT	ADVANCED DEVELOPMENT	ENGINEERING DEVELOPMENT		PRODUCTION/DEPLOYMENT	
PROGRAM REVIEWS	CONCEPT REVIEW	PRELIMINARY DESIGN REVIEW	CRITICAL DESIGN REVIEW	TEST READINESS REVIEW	OPERATIONAL READINESS REVIEWS	
CERTIFICATION REQUIREMENTS	CERTIFY CONCEPT REFLECTING LEAST R&M POTENTIAL RISK	CERTIFY BASELINE DESIGN WILL MEET DESIGN REQUIREMENTS	• CERTIFY DESIGN MEETS CONTRACT SPECIFICATION	CERTIFY HARDWARE READY FOR TEST	CERTIFY HARDWARE IS CAPABLE OF MEETING MISSION PERFORMANCE/ DESIGN REQUIREMENTS	D E P L O Y M E N T
REVIEW REQUIREMENTS	• EVALUATED PLANNED R&M TASKS • EVALUATE ALTERNATIVE TECHNICAL APPROACHES	• ESTABLISH MISSION AND ENVIRONMENTAL PROFILES • REVIEW PRELIMINARY FMEA • EVALUATE R&M TRADE OFF STUDIES • APPROVE PROBLEM PLAN	• STATUS OF PREVIOUS DESIGN REVIEW ACTIONS o △ FMEA • CONFIGURATION IS PER DESIGN DRAWINGS • REVIEW PRIOR TEST PROBLEMS	• TEST CONFIGURATION IS PER PRODUCTION DRAWINGS • TEST FACILITY CAN SUPPORT THE TEST o ALL PREVIOUS FAILURES HAVE BEEN CLOSED o TEST PROCEDURES ARE APPROVED AGAINST DESIGN REQUIREMENTS	• EVALUATE ACCEPTANCE TEST RESULTS o REVIEW ACCEPTANCE DATA PACKAGES o EVALUATE QUALITY TREND/PROBLEM DATA o EVALUATE ENGINEERING CHANGES/ MODIFICATIONS o VERIFY ALL FAILURES CLOSED o REVIEW ALL WAIVERS AND DEVIATIONS	

CHART 2

The chart depicts the interrelationships between hardware acquisition phases, program reviews and certification requirements when controls and disciplines are specified. Each program review is conducted usually just prior to progressing into the next program phase. It is the Navy's responsibility to conduct these reviews with the contractor providing the necessary technical support and documentation. Examples of the type of technical data considered at each program review are identified in review requirements.

Material Command should develop the in-house capability to define to the contractor the key elements required in reliability and quality programs. The program/acquisition manager must insure that contractor development and qualification testing is aimed at gaining knowledge and demonstrating performance, not merely reliability numerics. (16)

Testing must be done to develop understanding of the cause of failure which is the reason for poor reliability. And it is mandatory that testing be done in an environment which closely reflects the anticipated operational scenario as defined by the mission profile. Use of Navy hands-on testing (Fast Cruise Concept) may be an area for future expansion. The results of operator testing of the MK 92 FCS cited earlier have been encouraging and should help resolve follow-on problems.

Essentially, the entire concept of testing for reliability should evolve from the relatively static numeric requirements to a dynamic continuing program. The objectives established by the Navy manager for reliability and maintainability testing should not be to merely prove pre-determined standards. Rather, the objectives should be the definition of reasons for failure and corrective actions.

Inherent in these new concepts of reliability definition is the systems engineering approach. Characterized as the "Key to Reliability", the systems engineering approach

allows the program manager to anticipate, find, prevent and sustain reliability in his equipment or system. (21) Significantly, ADM Kidd defined these objectives in a 10 April 1974 memorandum in which "Policy for Reliability and Maintainability Requirements in Navy Programs" was clearly promulgated.

This memorandum provides the Navy manager with top level NAVMAT direction for the establishment of reliability and maintainability goals in each phase of the acquisition effort. Emphasis is initially placed on the definition of reliability requirements in the conceptual phase (including plans for demonstration and CNM level review). The validation and full scale development phases will stress the importance of testing and analysis. Achievement of reliability requirements must be demonstrated prior to the end of full scale development. Finally, the manager is directed to impose firm reliability requirements throughout the production phase. Contractor reliability efforts - including concepts such as failure free warranties - are to be continued during initial deployment phases. The memorandum concludes with direction from the Chief of Naval Material that each of his Systems Commanders and CNM designated Program Managers are to insure the required treatment of reliability and maintainability.

SECTION VII

CONCLUSIONS

The evidence and data developed during the research for this project clearly indicate the need for a revitalized Navy initiative in the areas of reliability and maintainability. This revitalization presents the Navy acquisition manager with an opportunity to both strengthen his own program as well as making a significant contribution to fleet readiness.

Although the NAVMAT Reliability and Maintainability Directorate has been in existence for just over four months, its impact is now being felt throughout the Navy acquisition world. The initial thrust of the directorate has been directed at those major problem areas outlined by the Wheeler Report. Certainly the initial actions recommended by the Wheeler Group have been accomplished. In this regard, the emphasis on R&M, the establishment of R&M directorates and the high level policy statements certainly satisfy the recommendation of the Wheeler Group. Individual directorates are now being established in each of the systems commands. The NAVSEA R&M Directorate recently had its charter approved and is expected to increase its influence in the near future.

Emphasis on reliability and maintainability appears to be increasing at the program office level. Both the DLGN-38 and the PF ship acquisition projects are reported to be stressing reliability as a major element in their programs. Emphasis is being placed on the creation of specific reliability engineer slots in these two project offices in order that proper attention might be given to this crucial area. Studies are being initiated by the NAVSEA R&M Directorate (SEA 06T) to review reliability procedures associated with equipment procurement (the concept of "Approved for Service Use").

There can be no doubt that the initial efforts have been proper and are at the highest levels of command. The power implied in the NAVMAT R&M Directorate Charter should be a significant force in future Navy acquisitions - if used properly. Admiral Kidd's 10 April 74 memo again restates his emphasis and direction. However, certain problems do exist which must be resolved. For example, the research data has disclosed no formal groups which would satisfy the requirement for an R&M action center. The NAVMAT Command Center does not appear to have assumed additional responsibility in this area. And no other formal NAVMAT group - other than the R&M Directorate-appears to exist.

The systems commands associated with surface ship

acquisition programs appear to be moving in the proper direction. The establishment of the R&M Directorates, required by NAVMAT Instruction, is on track and moving. But, the real test will be the capability of these organizations to penetrate the bureaucracies of their individual commands. As noted in the Wheeler Report:

> "... the primary problem is to get reliability built in from the beginning, and it is necessary to modify our procedures, cost allocations and management attitudes to do this." (5/2)

The initial efforts have been proper and correct. The emphasis on R&M visibility throughout the acquisition cycle is an important step. The efforts of the NAVMAT R&M Directorate to modify R&M testing procedures will also contribute to the required procedural modifications.

Significantly, the research conducted for this project indicates that current Navy efforts to improve reliability and maintainability appears to be adequate in all areas with the exception of perhaps the most critical one. And this is the area of applying sufficient financial resources to gain the advantages that reliability engineering can bring to fleet readiness. Unfortunately, in a Navy plagued with increasing financial costs, a major modernization program, and even a re-definition of mission, reliability still appears

to be a potential trade-off value. Only if there is a change in the management attitude which accepts - and relatively easily - this trade-off; only if there is a major commitment to reliability - - - then and only then can the lofty ideals and efforts succeed.

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